

DRILLING FLUID

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Application No. 60/460,878, filed April 8, 2003.

FIELD OF THE INVENTION

[0002] The present invention relates to drilling fluid and more particularly, the present invention relates to a drilling fluid composition adapted for use in high oil viscosity applications such as steam assisted gravity drainage (SAGD) and soak radial wells.

BACKGROUND OF THE INVENTION

[0003] In the existing technology, there is a wide variety of documents relating to drilling fluids and related materials.

[0004] It is known that drilling fluid, also referred to as drilling mud, is an important part of a drilling operation. The fluid is important to effect transport of debris, undesirable materials, gas etc. The fluid also functions to maintain lubrication and act as a coolant of the drill bit which experiences enormous force, friction and other stresses.

[0005] Typical of the presently used fluids is Kim Mud. This material provides high carrying capacity by an inherent thixotropic viscosity. The composition may contain potassium ions for reducing volume increases (swelling). This has the advantage of preventing hydration of moisture sensitive clays.

[0006] D-limonene has also been used in drilling fluid and is particularly favored in view of the fact that it is a natural substance extracted from citrus rind.

[0007] Various amines have also been used to augment drilling fluid and provide a variety of advantages in different operating conditions.

[0008] It would be desirable to have a fluid capable of cleaning tar out of sand and incorporate the oil in an emulsion with subsequent release. Most of the fluids in current use are based upon preventing the tar (heavy oil) from entering the mud.

SUMMARY OF THE INVENTION

[0009] One object of the present invention is to provide an improved drilling fluid which is not limited as the prior art compositions.

[0010] A further object of one embodiment of the present invention is to provide a drilling fluid for use in drilling high oil viscosity formations (tar, sand and oil entrained therein), comprising:

a water base viscosifying polymer in an amount from between .05% and 5% by volume;

a solvent in an amount from between 1% and 20%

by volume; and

a de-emulsifier in an amount from between .05% and 10% by volume.

[0011] Advantageously, the composition is environmentally friendly, results in greater than 90% sand removal and is resistant to common drilling contaminants such as solids, gypsum, lime and salt *inter alia*.

[0012] Perhaps one of the most important features of the composition is ease with which the emulsion is broken to provide the oil and water as discrete phases. By enzymatic action, the emulsion is de-emulsified and this has been observed over a wide temperature range. In fact, the emulsion is broken in the absence of energy input, a significant feature.

[0013] A still further object of one embodiment of the present invention is to provide a method of recovering oil from tar sands containing tar, oil and sand, comprising :

providing a composition containing a polymer, solvent for solving oil and tar from said tar sands and an emulsifier;

mixing compounds of said composition;

treating the tar sands with the composition to remove sand from the tar sands;

forming an emulsion with oil contained in treated tar sands where the emulsion is oil in water emulsion; and

de-emulsifying, under either energized or static conditions, the emulsion to release the oil as a separate phase from the water.

[0014] The composition in use has easily maintainable rheology and filtration control over a broad range of downhole operations.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] The following experiments are representative of the invention methodology and set forth experimental details in respect of the solution of the components of which the polymer system was made.

EXPERIMENT 1

[0016] A surfactant (Ho Flo) was evaluated in Kim Mud for its effect on tar sand. Testing was done at 30°C. It was found that Ho Flo at 0.1L/m³ in Kim Mud improves the clumping of tar sand oil and prevents the stickiness of the oil to the testing container.

EXPERIMENT 2

[0017] As an extension of Experiment No. 1, further testing was performed on Ho Flo surfactant in Kim Mud regarding its ability to prevent the tar sand oil from sticking to steel. Lab results showed no apparent sticking of oil to steel in straight Kim Mud. Consequently, Ho Flo was not required.

EXPERIMENT 3

[0018] Solubility of two tar sand samples was tested in DMO 100 at room temperature (23°C) and 35°C. At 23°C, DMO solubilized most of the tar leaving clean and freely moving sand. Temperature elevation to 35°C resulted in higher solubility and complete removal of the tar from sand.

EXPERIMENT 4

[0019] Four lubricants were tested in Stable K mud to select the one with the least effect on tar sand. Testing was done at 23°C and lubricant concentration of 1.5 and 3.0 kg/m³.

[0020] EZ Drill and EZ Drill II appeared to soften the tar sand, although no obvious sign of dissolvability of tar sand was noticed.

[0021] Tork-trol II and EZ Slide produced no change in the tar sand appearance.

EXPERIMENT 5

[0022] Stable K mud, Gel Chem mud, Stable K/K₂SO₄ mud and Polymer mud were evaluated for their ability to prevent blinding/sticking of bitumen from tar sands to screens. The testing temperature ranged from 5 to 20°C and the screens used were 50, 70, 84 and 110 mesh. The Stable K mud was tested at 25 and 30°C as well.

[0023] No blinding/sticking of bitumen to any screen occurred with any of the muds. The bitumen behaved the same in each mud.

EXPERIMENT 6

[0024] Various additives were tested in Polymer mud, Stable K mud and K₂SO₄ /Gel mud to select the best combination that water wets the shaker screen and prevents sticking of tar sands to screen.

[0025] Driltreat at 5L/m³ was the best additive improving the water wetting ability of all muds. K₂SO₄ worked similar in a Gel mud and less in Polymer mud. Q'Flow (Glycol) produced a softening of tar sands and dissolved some of the tar.

[0026] The second part of testing searched for an effective solvent of tar sands. Diesel, DMO 100 and HT-40N were tested at 23°C. The best solvent of tar from sand was Diesel with HT-40N being second best. DMO 100 was not found effective in removing the tar.

[0027] Experiments 7 - 9 represent lab work performed to develop a drilling fluid that solved the problems associated with drilling through tar sands. Thus, tar sand stickiness to equipment and shaker screen blinding was prevented with the new drilling fluid by removing the tar from the sand.

[0028] The idea behind the new drilling fluid was to formulate a direct emulsion where the external phase is water based and the internal phase is the organic solvent that removes the tar. Thus, the drilling fluid works by using the internal phase to clean the sand and keeping the removed oil in emulsion as fine drops. The emulsion is of loose structure and is readily broken or demulsified.

EXPERIMENT 7

[0029] The experiment relates to tests performed to select the organic solvent.

[0030] In order to find the best tar remover, over 50 products were tested at various concentrations. Q'Clean™ was selected as the best tar remover. Generally speaking, the product

comprises hydrogenated heavy petroleum naphtha together with an organic solvent.

[0031] While Q'Clean™ was found as the tar remover and internal phase in the new drilling fluid, the external (continuous) phase selected was a Polymer/Stable K fluid.

[0032] No emulsifiers were required. Testing showed that emulsifiers had an adverse reaction by creating too small a drop of Q'Clean™ in the drilling fluid reducing its ability for cleaning the sand.

[0033] The new drilling fluid, Polymer/Stable K/ Q'Clean™ was effective in removing the tar from the sand over a large range of temperatures, namely 5-30°C.

EXPERIMENT 8

[0034] This experiment sets forth work done to evaluate the performance of drilling fluid on a different sample of tar sands.

[0035] The Polymer/Stable K/Q'Clean™ fluid was tested at temperatures between 5 and 30°C on tar sand from ECR 3B 102 Leismer LSD 2/13-16-76-6w4. Testing confirmed that Polymer/Stable K/Q'Clean™ fluid worked very well; the tar sand was cleaned at the temperature range indicated.

EXPERIMENT 9

[0036] This experiment related to developing the optimum formulation for the drilling fluid. The objective was to find the drilling fluid that dissolved and incorporated the tar,

was least affected by contaminants and could be easily disposed of at the end of the well.

[0037] The project had 3 parts:

designing and testing for the optimum formulation of drilling fluid with regards to tar removing ability;

testing the likely contaminants on the fluid to see if any fluid formulation adjustment is required; and

testing for emulsion breaking and oil phase separation for fluid disposal at the end of the well.

[0038] A new drilling fluid formulation containing Polymers/sized Calcium Carbonate/ Q'Clean™ was designed and tested. Various viscosifiers were tested at different concentrations with regards to mud rheology, cleaning ability and effect on emulsion breaking.

[0039] The following fluid formulation was selected for its good rheology, fluid loss and tar sand cleaning ability:

PolyTar™ System

Kelzan XCD	0.75 kg/m ³
Staflor R	2 kg/m ³
Starpak DP	6 kg/m ³
Calcarb 325	10 kg/m ³
Calcarb 0	10 kg/m ³
Caustic Soda	pH 10
Q'Clean™	5 % v/v

[0040] Data illustrating the effectiveness will be presented herein after.

[0041] Contaminants testing on the drilling fluid showed minimal effects on its rheology and cleaning ability. Thus, gypsum and salt (NaCl) produced a moderate decrease in fluid rheology. The cleaning ability was affected only by salt; slightly reduced from 96% wt. to 80% wt. Solids contamination was simulated by adding 6% v/v tar sand to the drilling fluid already containing 5% v/v tar sand. The fluid behaved very well, cleaning 26% wt. tar sand off of the extra 6% v/v tar sand added.

[0042] After finding the fluid formulation and testing the contaminants, the environmental aspect of fluid development was reviewed. At the end of the well, the drilling fluid is a direct emulsion that contains as the internal phase (oil phase) the solvent (Q'Clean™) and the dissolved tar. In order to be able to dispose of the drilling fluid, the emulsion has to be broken and oil phase has to be separated and removed.

[0043] Breaking the emulsion of PolyTar™ System was attempted in three ways:

1. By making use of chemical demulsifiers. Eight demulsifiers were tested with no good results;
2. Making use of non-emulsifiers (two products) in the mud formulation to prevent the forming of a stable emulsion; and

3. Using a polymer breaker (four products, enzymes and bleach) to reduce the fluid viscosity and speed up the oil separation.

[0044] Q'Break™ (enzyme) at concentration of 2 kg/m³ is the best product to help with emulsion breaking and oil separation from the drilling fluid. It produces a fast reduction in mud viscosity, the emulsion breaks easily and the oil (Q'Clean™ +Tar) separates on top of fluid. After the treatment with Q'Break™ 2 kg/m³ and 24 hours static at 22°C, the oil left in emulsion in the mud was only 0.47 % v/v. Most of the oil phase (Q'Clean™ and dissolved Tar) was separated from the mud as a top layer and could be skimmed off.

[0045] Q'Break™ is an enzyme that works well at low temperatures, however, higher concentrations are recommended. Also, the product is safe and environmentally friendly.

[0046] A new approach to tar sand drilling resulted in development of a new drilling fluid addressing specific problems encountered in SAGD drilling projects.

[0047] The new drilling fluid was designed to solve the problem of tar sand stickiness by removing the tar from the sand. Lower toxicity and lower cost were pursued as attributes of the new drilling fluid designed.

[0048] Tables 1 and 2 set forth data and observations noted.

[0049] In respect of the drilling fluid composition, the following procedure was observed.

Various additives at various concentrations were added to water to examine the capacity to remove tar and clean the sand.

200 ml of the testing fluid received 20g of tar sands. The mixture was mixed on a Barnant mixer for 30 minutes at room temperature. The range of temperature for the testing was between 5°C and 30°C.

[0050] Table 1 tabulates the data and observations noted

Table 1

Fluid Additive selection

Additive & concentration in water	WTS, g	Visual observations
Blank (water)	19.580	Tar sands appeared unchanged. Fluid phase is clear and clean.
PAW 2315 @ 1% v/v	19.660	Tar sands appeared unchanged. Fluid phase is clear.
PAW 2315 @ 3% v/v	20.125	There is a very small amount of clean sand. The tar sand left is broken into smaller pieces; however, they remained hard. Fluid phase contains suspended small oil drops cleaned off the sand.
PAW 3900 @ 1% v/v	20.138	Similar to PAW 2315 @ 1% v/v.
PAW 3900 @ 3% v/v	20.632	There is a very small amount of clean sand. The tar sand left seems to remain in same size pieces; however, they remained hard. Fluid phase contains suspended small oil drops cleaned off the sand.
WAW 3917 @ 3% v/v	19.883	Similar to PAW 2315 @ 1% v/v.
WAO 3919U @ 3% v/v	20.281	Works well. Most sand is loose and fairly clean and the fluid phase is dark coloured. There are a few small soft pieces of tar sand left on the bottom of the beaker.
WAO 3919U @ 1% v/v	20.002	Similar to PAW 3919U @ 3% v/v. Just not quite as effective in cleaning the sand.
Beta Cyclod. @ 5 kg/m ³	20.420	There is a very small amount of clean sand. The tar sand left seems to remain in same size pieces. Fluid phase has a thin oily film on top. There are lost of small tar sand particles.
Beta Cyclod. @ 10 kg/m ³	21.940	No significant improvement.
Beta Cyclod. @ 20 kg/m ³	20.600	No significant improvement. Noticeable is the fact that 20 kg/m ³ appears to be above its solubility.
Cut Clean @ 1% v/v	20.283	There is a large amount of clean sand and large pieces of tar sand left. The fluid phase is clear with no suspended solids. It has an oily film and a ring at the surface.
Cut Clean @ 2% v/v	20.146	The tar sand is completely broken down. On top of the sand layer there is a layer of large oil globules separated when agitation ceased. The fluid phase is cloudy, tan, with the odd suspended globule of oil and a thick layer of oil on top.
Cut Clean @ 3% v/v	19.948	The sand is completely entrapped in what appears to be a water in oil emulsion on the bottom of the beaker. This very viscous layer with a gel like consistency is easily moved with agitation. The fluid phase is similar to the one above.
Mudd Lite @ 2% v/v	20.885	Tar sands appeared unchanged. Fluid phase is tan in colour and has a layer of foam on top.
Mudd Lite @ 6% v/v	19.962	Similar to Mudd Lite @ 2% v/v.
DH6-115-2	19.802	Tar sands appeared unchanged. Fluid phase is clear.
EX107 @ 3% v/v	20.800	Tar sands appeared unchanged. Fluid phase is clear.
EX1501 @ 3% v/v	20.670	There is a very small amount of clean sand. The tar sand left seems to remain in same size pieces. In water, this additive coagulated in a cream-yellow layer that separates on top of the fluid phase when at rest.
EXA923 @ 3% v/v	20.791	Tar sands appeared unchanged. Fluid phase is clear.

Table 1 cont'd

E X1033 @ 3% v/v	19.703	It broke the large tar sand pieces into small ones but there is no clean sand.
S DN82 @ 3% v/v	20.799	The sand is completely entrapped in what appears to be a water in oil emulsion on the bottom of the beaker. The liquid phase above this bottom layer is clean and clear.
E X1557 @ 3% v/v	19.600	~ 75% of tar sand is completely clean. The rest of tar sand is in pieces looking unchanged. Under the microscope can see the oil in water emulsion that has a dark colour. There is a thin film of oil on top of fluid phase.
E X1557 @ 1% v/v	20.557	Similar to above test, just that on the sand grains are not quite as clean.
E X1557 @ 5% v/v		Same as @ 3% v/v.
E X 606 @ 3% v/v	20.903	There is a very small amount of clean sand. The tar sand left seems to remain in same size pieces. The fluid phase is light tan in colour and contains few tar particles suspended.
E X 109 @ 3% v/v	19.282	~ 75% of tar sand is completely clean. The rest of tar sand is in pieces looking unchanged. Under the microscope can see the fluid as oil in water emulsion that has a dark colour. There is a thin film of oil on top of fluid phase.
E X 109 @ 5% v/v	20.104	Same as @ 3% v/v.
S DN71 @ 3% v/v	20.120	~ 50% of sand is partially clean and the other 50% is left unchanged in tar sand pieces. The fluid phase is oil in water emulsion.
S DN120 @ 3% v/v	20.322	There is less than 1% of clean sand. The tar sand left seems to remain in same size pieces. The fluid phase is clean and clear.

Fluid Additive selection

Additive & concentration in water	WTS, g	Visual observations
S DN114 @ 3% v/v	19.820	As above
S DN121 @ 3% v/v	20.026	~ 15 - 20% of sand is clean. The rest appears unchanged. The fluid phase is milky-gray in colour.
S DN87 @ 3% v/v	20.735	~ 75% of sand is completely clean. The rest of tar sand is in fairly small pieces. Under the microscope can see the fluid as oil in water emulsion that has a dark colour.
S DN87 @ 3% v/v	20.610	Some improvement from 3% v/v, however, there still are a few tar sand pieces left.
S DN76 @ 3% v/v	21.028	Most of tar sand (~75%) is a flowing sludge on the bottom of beaker. There are a few pieces of tar sand
DT78 @ 3% v/v	20.782	~ 80 - 90% of sand is fairly clean but the oil is not emulsified and just lays and sticks to the sand layer.
DG56 @ 3% v/v	20.980	There is less than 1% of clean sand. The tar sand left seems to remain in same size pieces. The fluid phase is clean and clear.
M38 @ 3% v/v	20.853	~ 50% of sand is fairly clean and the other 50% is left small tar sand pieces. The fluid phase is oil in water emulsion.
M150 @ 3% v/v	19.320	~ 50% of loose sand, dark, still coated with oil. The rest of tar sand seems to remain in same size pieces. The fluid phase is dark
M192 @ 3% v/v	20.962	~ 75% of tar sand is completely clean. The rest of tar sand is in pieces looking unchanged. Under the microscope can see the oil in water emulsion that has a dark colour. There is a thin film of oil on top.
M192 @ 5% v/v	20.042	Some improvement from 3% v/v, however there still are a few tar sand pieces left.
M187 @ 3% v/v	20.178	~ 15 - 20% of sand is clean. The rest appears unchanged. The fluid phase is tan in colour.
Solvent @ 5% v/v	19.314	~ 80% of sand is loose, free flowing but still covered by oil material
P2-181-9 @ 1% v/v	20.386	~ 50% of sand is fairly clean and the other 50% is left small tar sand pieces. The fluid phase is an emulsion.
P2-181-11B @ 1% v/v	20.408	~ 15 - 20% of sand is clean. The rest appears unchanged.
P2-181-15B @ 1% v/v	20.560	~ 50% of sand is fairly clean and the other 50% is left small tar sand pieces. The fluid phase is an emulsion.
P2-181-19B @ 1% v/v	21.300	Complete balling of tar sands that became soft (it incorporated water) and sticky.
P2-181-16B @ 1% v/v	21.107	~ 15 - 20% of sand is clean. The rest appears unchanged.
P2-181-21B @ 1% v/v	20.144	~ 15 - 20% of sand is clean. The rest of tar sand is soft and sticky.
Travis 2095 @ 1% v/v	21.893	~ 5% of sand is clean. The rest appears unchanged.
Travis 2704 @ 1% v/v	20.982	Tar sands appeared unchanged. Fluid phase is clear.

Table 1 cont'd

Drilling Fluid selection – Polymer/Stable K system

Additive & concentration In drilling fluid	WTS, g	Visual Observations
Blank (Poly./Stable K)		
E XZ1557 @ 1% v/v	20.634	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
E XZ1557 @ 3% v/v	20.049	~ 40% of tar sand remained on the 30 mesh screen as small and large pieces. Dark fluid phase of oil in water emulsion.
Xylene/Isopropanol @ 3% v/v	20.250	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
Diesel @ 3% v/v	20.975	There is a small amount of loose sand. Tar sand left remained in same size pieces. Fluid phase is emulsion with suspended tar particles.
Diesel @ 10% v/v	19.580	Most solids are loose, still covered by oil and flowing.
Diesel @ 10% v/v + XZ1557@3% v/v	20.078	Tar sands appeared unchanged. The oil is emulsified as extremely small drops that could not contact the tar sands and is fairly clean.
BDD100 @ 3% v/v	20.980	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
BDS300 @3% v/v	19.047	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
BDS200 @3% v/v	20.382	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
E X1577 @3% v/v	20.490	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
E X1421 @3% v/v	20.195	It produced rapid precipitation-coagulation of the Polymer/Stable K system.
E X1262 @3% v/v	20.728	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
E X1667 @3% v/v	20.801	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
DWB-1-5 @3% v/v	20.221	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
DWB-1-9 @3% v/v	20.453	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
DWB-1-6 @3% v/v	20.735	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
DWB-1-7 @3% v/v	20.466	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
DWB-1-8 @3% v/v	19.952	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
Solvent @ 3% v/v + XZ1557 @ 1% v/v	20.942	Some clean sand grains seen under microscope. Most tar sand is left uncleaned as small pieces.
Solvent @ 10% v/v	20.631	Cleaned most of sand. Mixture is poured on a 30 mesh screen. ~ 10% of tar sand remained on the screen. Can see the clear - clean sand grains suspended in the fluid and the dark oil drops. Fluid phase is very dark due to the dissolved oil.
Solvent @ 10% v/v + Rev Dust 4% v/v	20.17	< 5% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase containing almost completely clean sand.
Solvent @ 7% v/v + Rev Dust 4% v/v	20.353	~5 - 7 % of tar sand left on the 30 mesh screen. The rest as above.
M192 @ 5% v/v	20.824	~ 70% of tar sand remained on the 30 mesh screen as small and large pieces. Dark fluid phase.
Amodrill 1400 @ 10% v/v	20.560	~ 30% of tar sand remained on the 30 mesh screen as small and large pieces. Dark fluid phase.
Emulam D30 @ 5% v/v	20.106	~ 100% of tar sand remained on the 30 mesh screen as unchanged small and large pieces.
Cut Clean @ 5% v/v	20.929	~ 30% of tar sand remained on the 30 mesh screen as small and large pieces. Dark fluid phase.

Table 1 cont'd

Drilling Fluid selection – Gel Chem system

Additive & concentration in drilling fluid	WTS, g	Visual Observations
Blank (Gel Chem sys.)	20.651	Tar sands appeared unchanged. Fluid phase contains small tar particles suspended.
Tar Solvent @ 10% v/v	20.920	~ 20% of tar sand remained on the 30 mesh screen as small and large pieces. Dark fluid phase with fairly clean sand suspended.
Tar Solvent @ 10% v/v + Rev Dust @ 4% v/v	20.700	As above.

Additive concentration and mixture temperature	WTS, g	Visual Observations
Tar Solvent @ 20% v/v - 5°C	20.878	~ 10% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase containing almost completely sand.
Tar Solvent @ 10% v/v - 10°C	19.968	~ 50% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase.
Tar Solvent @ 15% v/v - 10°C	20.261	~ 20% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase.
Tar Solvent @ 20% v/v - 10°C	20.325	~ 10% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase containing almost completely sand.
Tar Solvent @ 15% v/v - 15°C	20.380	~ 20% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase.
Tar Solvent @ 20% v/v - 15°C	20.375	~ 10% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase containing almost completely sand.
Tar Solvent @ 10% v/v - 20°C	20.713	~ 5% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase containing almost completely sand.
Tar Solvent @ 10% v/v - 25°C	20.532	As above
Tar Solvent @ 10% v/v - 30°C	20.342	~ 3% of tar sand left on the 30 mesh screen as small and soft pieces. Dark fluid phase containing almost completely sand.

[0051] In connection with the fluid testing, the following procedure was involved.

200 mL of drilling fluid, discussed herein previously, was placed in a beaker to which 20 g of Tar Sands was added. This was mixed on a Barnant mixer for 30 minutes at room temperature. The mixture was passed through a 30 mesh screen.

[0052] The test was repeated in a temperature range of between 5 and 30°C.

Table 2

Tar sands from 397.4m depth - Drilling fluid testing

Solvent concentration in drilling fluid and test temperature	WTS, g	Visual Observations
15% v/v Solvent & 5°C	20.450	~ 15-20% of tar sand left on the 30 mesh screen (small and large pieces) and a significant amount of clean large sand grains (~3mm diameter). Dark fluid phase containing completely clean sand
20% v/v Solvent & 5°C	19.781	~ 10% of tar sand left on the 30 mesh screen (small and large pieces) and a significant amount of clean large sand grains (~3mm diameter). Dark fluid phase containing completely clean sand
10% v/v Solvent & 10°C	19.968	~ 20% of tar sand left on the 30 mesh screen as various size pieces. The rest is as above.
15% v/v Solvent & 10°C	20.261	~ 15% of tar sand left on the 30 mesh screen as various size pieces. The rest is as above.
20% v/v Solvent & 10°C	20.371	~ 7-10% of tar sand left on the 30 mesh screen as small and soft pieces. The rest is as above.
10% v/v Solvent & 15°C	20.482	~ 15% of tar sand left on the 30 mesh screen as various size pieces. The rest is as above.
15% v/v Solvent & 15°C	20.037	~ 15% of tar sand left on the 30 mesh screen as various size pieces. The rest is as above.
20% v/v Solvent & 20°C	20.389	~ 3% of tar sand left on the 30 mesh screen as small size pieces. The rest is as above.
0% v/v Solvent & 20°C	20.253	~ 80% of tar sand left on the 30 mesh screen as small size pieces. The solids that passed through the screen are suspended in the fluid and consist of tar sands and heavy oil particles.
10% v/v Solvent & 20°C	20.135	~ 7-10% of tar sand left on the 30 mesh screen (small and large pieces) and a significant amount of clean large sand grains (~3mm diameter). Dark fluid phase containing completely clean sand
10% v/v Solvent & 25°C	20.185	~ 5% of tar sand left on the 30 mesh screen as various size pieces. The rest is as above.
10% v/v Solvent & 30°C	20.019	No tar sand left on the 30 mesh screen. The only solids left on screen are the clean large sand grains (~3mm diameter). Dark fluid phase containing completely clean sand.

Note: WTS - weight of tar sands.

[0053] In all the above tests where the new drilling fluid was used (all except sample with 0% v/v Solvent), the fluid phase was an oil in water emulsion. The oil drops had a good size (not too small, not too big) and were dark colored due to the tar having been stripped off the sand.

[0054] The core sample of tar sands used to perform the above testing showed very small pieces of completely clean solids

(shale like). These clean solids were avoided when tar sand samples were removed from the core during testing.

[0055] Tables 3 through 22 tabulate data for different polymer systems together with specific listing for each.

[0056] As set forth herein previously, having listed the necessary components for the polymer system, ranges for effectiveness were required for determination. The following two polymer systems were tested

Polymer System A

Additive	Concentration
Kelzan XCD [®]	1.5 kg/m ³
Staflor [®] R	2 kg/m ³
Starpak [®] DP	6 kg/m ³
Calcarb 325	10 kg/m ³
Calcarb 0	10 kg/m ³
Caustic Soda	pH 10

Polymer System B

Additive	Concentration
Kelzan XCD [®]	2 kg/m ³
Staflor [®] R	2 kg/m ³
Starpak [®] DP	6 kg/m ³
Calcarb 325	10 kg/m ³
Calcarb 0	10 kg/m ³
Caustic Soda	pH 10

Q/C = Q'Clean

Table 3**Mud Formulation Testing - Rheology and API fluid loss at 23°C**

Formulation	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa	FL, mL
A	65	47	40	30	23	17	8	7	3.5/4.0	18	14.5	13.8
A + 2.5%Q'C	66	49	41	30	24	18	8	7	3.5/4.0	18	16.0	12.0
A + 5%Q'C	70	52	43	32	25	18	9	8	4.0/4.5	18	17.0	9.8
A + 10%Q'C	71	52	43	32	25	19	9	8	4.5/4.5	19	16.5	8.3
B	101	78	67	48	40	30	12	10	4.5/5.0	23	27.5	11.2
B + 2.5%Q'C	105	81	69	52	41	30	13	11	5.0/5.5	24	28.5	11.0
B + 5%Q'C	110	84	72	54	43	31	14	11	5.5/5.5	26	29.0	12.4
B + 10%Q'C	115	89	75	57	46	33	15	12	6.0/6.0	26	31.5	9.0

Table 4**Tar Sand Cleaning at 23°C**

Fluid Formulation	Weight, g				Tar sand cleaned, % wt.
	Tar sand	Dish	Residue & Dish	Residue > 30 mesh	
A	27.131	1.060	23.013	21.953	19.1
A + 2.5%Q'C	27.122	1.000	7.890	6.890	74.6
A + 5%Q'C	27.300	1.033	2.112	1.079	96.0
A + 10%Q'C	27.644	1.004	1.671	0.667	97.6
B	27.233	1.039	23.474	22.435	17.6
B + 2.5%Q'C	27.473	1.038	8.375	7.337	73.3
B + 5%Q'C	27.457	1.031	2.718	1.687	93.9
B + 10%Q'C	27.295	1.038	2.273	1.235	95.5

Table 5**Contaminants Testing on the PolyTar System (PTS = A + 5%Q'C). Rheology at 23°C**

Sample	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa
PTS	64	47	39	28	23	16	8	6	3.0/3.5	17	15
PTS + 5 kg/m ³ Gypsum	48	35	29	20	16	12	5	4	2.5/2.5	13	11
PTS + 1 kg/m ³ Lime	64	47	39	28	23	16	8	6	3.0/3.5	17	15
PTS + NaOH for pH12	62	46	38	28	22	15	7	5	3.0/3.0	16	15
PTS + 5 kg/m ³ NaCl	56	41	34	24	19	13	6	5	2.5/3.0	15	13
PTS + 10 kg/m ³ NaCl	54	39	32	23	18	13	6	5	2.5/3.0	15	12
PTS + 20 kg/m ³ NaCl	49	35	29	21	16	11	5	4	2.0/2.5	14	10.5
PTS + 6% vol. Tar Sand	72	52	42	31	24	18	9	6	3.0/3.5	20	16

Table 6

Contaminants Testing on the PolyTar System (PTS). API fluid loss

Sample	FL, mL
PTS	10
PTS + 5 kg/m ³ Gypsum	9.5
PTS + 1 kg/m ³ Lime	10
PTS + 5 kg/m ³ NaCl	9.5
PTS + 10 kg/m ³ NaCl	9
PTS + 20 kg/m ³ NaCl	8
PTS + 6% vol. Tar Sand	6

Table 7

Tar Sand Cleaning in contaminated fluid at 23°C - 5% vol. Tar Sand in the Fluid Sample

Fluid Sample	Weight, g				Tar sand cleaned, % wt.
	Tar sand	Dish	Residue & Dish	Residue > 30 mesh	
PolyTar System (PTS)	27.300	1.033	2.112	1.079	96.0
PTS + 5 kg/m ³ Gypsum	27.611	1.002	2.882	1.880	93.2
PTS + 1 kg/m ³ Lime	27.273	1.027	2.527	1.500	94.5
PTS + 5 kg/m ³ NaCl	27.458	0.998	5.720	4.722	82.8
PTS + 10 kg/m ³ NaCl	27.397	1.004	6.278	5.274	80.7
PTS + 20 kg/m ³ NaCl	27.315	1.004	6.425	5.421	80.2
PTS + 6% vol. Tar Sand	27.289	1.020	21.099	20.079	26.4

Table 8

PolyTar System/Dissolved Tar Emulsion Breaking at 23°C - Removal of dissolved tar.

Demulsifier	Conc., L/m ³	Notes on emulsion behaviour
None		Oil drops are small but visible with naked eye. The oil in water emulsion is stable. It does not break in over 8 hours. After 24 hours there is a very small amount of free oil on top of fluid.
T2001	1	Oil drops are not visible with naked eye. Under the microscope they look 2 - 3 times smaller than they were initially. The oil in water emulsion became more stable. It does not break in over 24 hours. There is no free oil on top of fluid.
	2	
T2005	1	Oil drops are not visible with naked eye. Under the microscope they look 2 - 3 times smaller than they were initially. The oil in water emulsion became more stable. It does not break in over 24 hours. There is no free oil on top of fluid.
	2	
T2007	1	Oil drops are not visible with naked eye. Under the microscope they look 2 - 3 times smaller than they were initially. The oil in water emulsion became more stable. It does not break in over 24 hours. There is no free oil on top of fluid.
	2	
T2508	1	Oil drops are not visible with naked eye. Under the microscope they look 2 - 3 times smaller than they were initially. The oil in water emulsion became more stable. It does not break in over 24 hours. There is no free oil on top of fluid.
	2	
NE 125	0.5	Oil drops are small but visible with naked eye. The oil in water emulsion is stable. It does not break in over 8 hours. After 24 hours there is a very small amount of free oil on top of fluid.
	1	
NE 723	0.5	Oil drops are small but visible with naked eye. The oil in water emulsion is stable. It does not break in over 8 hours. After 24 hours there is a very small amount of free oil on top of fluid.
	1	
	2	

Table 9

PolyTar System/Dissolved Tar Emulsion - Preventing forming a stable emulsion using non-emulsifiers (23°C) .		
Non-emulsifier	Conc., L/m ³	Notes on emulsion behaviour
None		Oil drops are small but visible with naked eye. The oil in water emulsion is stable. It does not break in over 8 hours. After 24 hours there is a very small amount of free oil on top of fluid.
NE 125	1 2	Oil drops are not visible with naked eye. Under the microscope they look 2 - 3 times smaller than they were initially. The oil in water emulsion became more stable. It does not break in over 24 hours. There is no free oil on top of fluid.
NE 723	1 2	Oil drops are not visible with naked eye. Under the microscope they look 2 - 3 times smaller than they were initially. The oil in water emulsion became more stable. It does not break in over 24 hours. There is no free oil on top of fluid.

Table 10**Tar Sand Cleaning at 23°C - PTS cleaning ability when using non-emulsifiers at 1L/m³.**

Non-emulsifier	Weight, g				Tar sand cleaned, % wt.
	Tar sand	Dish	Residue & Dish	Residue > 30 mesh	
NE 125	27.655	1.036	13.601	12.565	54.6
NE 723	27.504	1.000	8.898	8.898	67.6

Table 11**Viscosifier selection to prevent forming a stable PolyTar System/Dissolved Tar Emulsion - Polymer (Viscosifier) Testing in PolyTar System - Rheology at 23°C .**

Viscosifier	kg/m ³	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Geis, Pa	PV, cP	YP, Pa
Kelzan XCD	1.5	70	52	43	32	25	18	9	8	4/4.5	18	17
Blovis	1.5	54	37	29	18	13	8	3	2	1/1.5	27	5
Blovis	3	73	53	44	33	27	20	10	8	4.5/6.5	20	16.5
Geovis XT	1.5	71	51	42	32	25	19	10	9	5/7	20	15.5
HEC	1.5	92	70	58	43	33	23	9	7	3.5/3.5	22	24
Xanvis	1.5	60	43	36	26	20	15	7	6	3/3.5	17	13

Table 12

Tar Sand Cleaning at 23°C - PTS cleaning ability when using viscosifiers and concentrations above mentioned.

Viscosifier	Weight, g				Tar sand cleaned, % wt.
	Tar sand	Dish	Residue & Dish	Residue > 30 mesh	
Kelzan XCD	27.300	1.033	2.112	1.079	96.0
Biovis - 1.5	27.345	1.009	5.076	4.067	85.1
Biovis - 3	27.474	1.033	3.398	2.365	91.4
Geovis XT	27.343	1.020	4.354	3.334	87.8
HEC	27.456	1.031	9.140	8.109	70.5
Xanvis	27.333	1.002	4.638	3.636	86.7

Table 13

Viscosifier selection to prevent forming a stable PolyTar System/Dissolved Tar Emulsion - Testing at 23°C.

Viscosifier	Conc., kg/m ³	Notes on emulsion behaviour within 6 hours
Kelzan XCD	1.5	The oil in water emulsion is less stable. Emulsion is slowly breaking. There is a bit of free oil on top of fluid after 6 hours. This sample looks the best.
Biovis	3	The oil in water emulsion is stable. No sign of emulsion breaking in 6 hours. There is no free oil on top of fluid.
Geovis XT	1.5	The oil in water emulsion is stable. No sign of emulsion breaking in 6 hours. There is no free oil on top of fluid.
HEC	1.5	The oil in water emulsion is stable. No sign of emulsion breaking in 6 hours. There is no free oil on top of fluid.
Xanvis	1.5	The oil in water emulsion appears less stable. Emulsion is slowly breaking. There are traces of free oil on top of fluid after 6 hours. This sample is the next best.

Table 14

Polymer Breaker Testing on PTS containing Kelzan XCD @ 1.5 kg/m³ - Rheology after 24 hours @ 23°C

Breaker & conc., kg/m ³	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa
None	66	48	41	30	24	17	8	6	3/3.5	18	15
Q'Break, 2	41	28	22	15	11	8	4	3	1.5/1.5	13	7.5
Chembreak HC, 3	41	27	22	15	11	8	3	2	1/1.5	14	6.5
Chembreak EBS, 3	52	38	31	22	17	12	6	5	2.5/3	14	12
Chembreak EBS, 3 *	48	34	28	20	16	11	5	4	2/2	14	10
Bleach, 5 L/m ³	26	17	13	9	7	5	2	2	1/1	9	4

Note: * - sample contains 5,000 ppm Cl⁻ as NaCl.

[0057] An adjusted polymer system was then reviewed.

Adjusted PolyTar System formulation (less viscosifier)

Additive	Concentration
Kelzan XCD [®]	.75 kg/m ³
Staflor [®] R	2 kg/m ³
Starpak [®] DP	6 kg/m ³
Calcarb 325	10 kg/m ³
Calcarb 0	10 kg/m ³
Caustic Soda	pH 10
Q'Clean	5% vol.

Additive	Concentration
Xanvis [®]	1 kg/m ³
Staflor [®] R	2 kg/m ³
Starpak [®] DP	6 kg/m ³
Calcarb 325	10 kg/m ³
Calcarb 0	10 kg/m ³
Caustic Soda	pH 10
Q'Clean	5% vol.

Table 15

PolyTar System/Dissolved Tar Emulsion (5% vol. Tar Sand in the mud) - Rheology at 23°C.

Viscosifier	kg/m ³	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa
Kelzan XCD	0.75	58	42	34	24	18	12	5	4	2/2	16	13
Xanvis	1	62	46	38	27	21	15	6	5	2.5/3	16	15

Table 16

Tar Sand Cleaning at 23°C - PTS cleaning ability when using viscosifiers and concentrations above mentioned.

Viscosifier	Weight, g				Tar sand cleaned, % wt.
	Tar sand	Dish	Residue & Dish	Residue > 30 mesh	
Kelzan XCD	27.397	1.059	4.116	3.057	88.8
Xanvis	27.512	1.040	5.076	4.378	84.1

Table 17**Polymer Breaker Testing on PTS containing Kelzan XCD @ 0.75 kg/m³ - Rheology after 2 hours @ 23°C**

Breaker & conc., kg/m ³	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa
None	58	42	34	24	18	12	5	4	2/2	16	13
Q'Break, 2	41	25	19	12	9	5	2	2	1/1	16	4.5
Chembreak HC, 3	27	17	13	8	5	4	1	1	0.5/0.5	10	3.5
Bleach, 5 L/m ³	56	36	27	17	13	8	3	2	1/1	20	8

Table 18**Polymer Breaker Testing on PTS containing Xanvis @ 1 kg/m³ - Rheology after 2 hours @ 23°C**

Breaker & conc., kg/m ³	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa
None	62	46	38	27	21	15	6	5	2.5/3	16	15
Q'Break, 2	44	28	22	14	10	7	3	2	1/1	16	6
Chembreak HC, 3	41	28	22	15	11	7	3	2	1/1	13	7.5
Bleach, 5 L/m ³	69	47	38	25	19	13	5	4	2/2.5	22	12.5

Table 19**Retort Test on PolyTar System/Dissolved Tar Emulsion (5% vol. Tar Sand in the mud)**

Sample from 1/2 height of emulsion in 250 mL graduated cylinder after 24 hours	Retort content, % v/v			Total Hydrocarbons Content (Core Labs), % v/v
	Oil	Water	Solids	
Blank (no ECA)	5	94	1	
Q'Break 2 kg/m ³	2	97	1	0.473
Q'Break 4 kg/m ³	1	99	0	0.492

Table 20**Q'Break Testing at 23°C (room) on PTS containing Kelzan XCD @ 0.75 kg/m³ - Rheology @ 23°C**

Q'Break kg/m ³	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa
None	58	42	34	24	18	12	5	4	2/2	16	13
2 kg/m ³ , after 2 hours	40	26	20	13	9	6	2	2	1/1	14	6
2 kg/m ³ , after 6 hours	36	23	18	11	8	5	2	1	0.5/0.5	13	5
2 kg/m ³ , after 24 hours	31	20	15	10	7	4	1	1	0.5/0.5	11	4.5
4 kg/m ³ , after 2 hours	39	25	20	13	9	6	2	2	1/1	14	5.5
4 kg/m ³ , after 6 hours	25	16	12	7	5	3	1	1	0.5/0.5	9	3.5
4 kg/m ³ , after 24 hours	20	12	9	6	4	3	1	1	0.5/0.5	8	2

Table 21**Q'Break Testing at 3°C (fridge) on PTS containing Kelzan XCD @ 0.75 kg/m³ - Rheology @ 3°C**

Q'Break, kg/m ³	600 rpm	300 rpm	200 rpm	100 rpm	60 rpm	30 rpm	6 rpm	3 rpm	Gels, Pa	PV, cP	YP, Pa
None	74	52	43	30	23	16	7	5	2.5/3	22	15
2 kg/m ³ , after 3 hours	54	35	27	17	12	8	3	2	1/1	19	8
2 kg/m ³ , after 6 hours	40	25	19	12	9	5	2	1	0.5/0.5	15	5
4 kg/m ³ , after 2 hours	47	31	23	15	11	7	2	2	1/1	16	7.5
4 kg/m ³ , after 6 hours	38	24	17	11	8	5	2	1	0.5/0.5	14	5

Table 22**Emulsion Breaking using both Q'Break 2 kg/m³, let sit 3 hours then add demulsifier. Testing at 23°C.**

Demulsifier	Conc., L/m ³	Notes on emulsion behaviour - 250 mL sample in a graduated glass cylinder.
None (Blank)		Emulsion is slowly breaking. There is a a layer of ~12 mL of very dark fluid on top after 3 hours. Large oil drops form and accumulate towards top of fluid. After 48 hours the sample shows a very good oil separation. After 1 week there is the oil layer on top, clear water phase in the middle and solids layer on bottom.
RD2069	1	Upon mixing the RD2069 demulsifier, there was a stringy, gummy precipitate formed. Otherwise, the sample looks similar to the blank but having smaller oil drops accumulating towards the top. Demulsifier cannot be used due to chemical incompatibility with mud components (precipitation).
T2005	1	Emulsion seems to very slowly break. There is a a layer of ~9 mL of very dark fluid on top with a definite separation from the lighter layer beneath after 3 hours. However, the rest of the fluid shows no sign of forming visible oil drops. After 48 hours the sample shows the least oil separation of all. After 1 week the is a layer of oil separated but the rest of the fluid is muddy and seems to contain traces of oil.
JC91-6B	1	Emulsion is slowly breaking. There is a a layer of ~12 mL of very dark fluid on top after 3 hours. Large oil drops form and accumulate towards top of fluid. After 48 hours the sample shows a very good oil separation same as the blank. After 1 week there is the oil layer, clear water phase and solids layer similar to the blank.

[0058] Overall the polymer system containing the Kelzan XCD® in a concentration of 0.75 kg/m³ provided preferred rheology, fluid loss and cleansing of tar sands.

FIELD EXAMPLE

[0059] In January/February of 2004, six wells were drilled which used the PolyTar drilling fluid system in part of the drilling operation. The wells, located in 84-11 W4 in Alberta Canada, were horizontal in nature with the intermediate and main horizontal tar sands drilled with Polytar. The nature of sand was one of ~ 23 v/v% bitumen contained within a ~ 3 milliDarcy permeable poorly consolidated matrix.

[0060] Typical drilling conditions with Polytar are ~ 400 meters of drilled 311 mm intermediate hole with casing set at 90° inclination from vertical. The 222 mm horizontal section was ~ 600 meters in length. The following table highlights some of the Polytar drilling parameters as compared to other water-based muds used in the same 84-11 W4 area.

Table 23**Drilling Fluid Performance of Bitumen Laden Sands**

System(year)	# of wells	Average m drilled	Average days to TD	Average mud cost	Typical shaker screen design
K ₂ SO ₄ polymer (1998)	4	1077	4.8	\$27,755	38 * 38 * 38
K ₂ SO ₄ polymer (1998)	6	1357	4.6	\$10,280	38 * 38 * 38
KCl polymer (2003)	4	1505	8.8	\$43,907	84 * 50 * 38 * 20 140 * 110 * 84 * 50
Polytar (2004)	6	1078	3.9	\$22,531	210*175*175*145 210*210*180*145

[0061] The data shows that the Polytar system has been cost effective. Days to total depth were similar to the 6 well project using K₂SO₄ polymer and faster than the KCl polymer

and K_2SO_4 polymer (4 wells) groupings. Drilling fluid costs for the Polytar system were also very competitive.

[0062] The average shaker screen sizes used on the Polytar system were much finer than those used on the other three system groupings. The potassium based systems, which used the larger screen sizes, were designed to carry the insoluble bitumen to surface intact. Typical of these potassium systems however, the bitumen accretes onto metallic surfaces. The shaker screens become less effective when accretion occurs, thus the need for larger screen openings.

[0063] The Polytar system solubilizes at least part of the bitumen into the drilling fluid system, thus eliminating accretion and increasing the efficiency of the shaker screens. As a result, cleaning of the drilling fluid system of drilled sand is improved. The sand collected from the shaker screen from the bitumen laden drilled solids contained typically less than 0.5% v/v oil.

[0064] The Polytar wells at 84-11 W4 employed centrifuges for additional drilling fluids cleaning functions. In general, the sand coming from the centrifuge underflow was clean enough to meet mix-bury-cover regulations within Alberta. The following tables set out the analyses received from centrifuge underflows at 700 m and 800 m measured depths.

Table 24:**Hydrocarbon content from Centrifuge Underflows with Polytar**

Subsoil Density = 1820 kg/m ³ ; soil:waste mix ratio 3:1			
Waste Densities = 2020 and 1975 kg/m ³ for 700m and 800m			
	700m Analyses	800 m Analyses	Closure Criteria
Benzene	0	0	0.073
Toluene	0	0	0.86
Ethylbenzene	0	0	0.19
Xylenes	0	0	25
Fraction 1	0	0	260
Fraction 2	170	216	900
Fraction 3	169	212	800
Fraction 4	68	85	5600
Total HC's	407	513	

[0065] The embodiments of the invention described above are intended to be exemplary only. The scope of the invention is therefore intended to be limited solely by the scope of the appended claims.